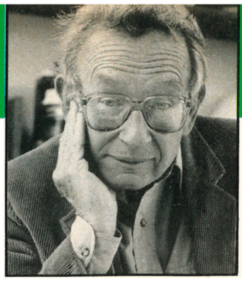

COMPLEXITY II: THE SANTA FE INSTITUTE

Philip W. Anderson

It was with a sense of pride that, the other day, I realized I should update my curriculum vitae to include the phrase "External Professor, Santa Fe Institute, 1989–."

What in Heaven's name, you may ask, is the Santa Fe Institute? And why am I proud of being a spear-carrier (officially, second vice chairman of the science board as well as "external professor") at this unknown place? The answer calls for a brief history and for the explanation of two central ideas: "emerging syntheses" and "complex adaptive systems."

In the early 1980s a group of friends centered around Los Alamos and Santa Fe, led by George Cowan and including Murray Gell-Mann, Herb Anderson, Mike Simmons, Peter Carruthers and Nick Metropolis as well as quite a number of others, began to discuss doing something about one of the sociological peculiarities of science: that most scientific revolutions (contrary to Thomas Kuhn's well-known description) occur *outside* or *between* the established areas of science that are enshrined in our universities' departmental structures and in the funding agencies. Radioastronomy, molecular biology, solid-state physics, quantum optics and the like did not grow up in university departments devoted to those subjects or even in predecessor departments of astronomy, biology or physics. Rather, these fields emerged at a variety of institutions characterized by flexibility—in the power vacuum of the post-Rutherford Cavendish Laboratory, at the Rockefeller Institute and at Bell Laboratories, among other places. "Chaos," for instance, began with a meteorologist and some mathematicians and population biologists, and it matured in a 1960s-type collective atmosphere at Santa Cruz.

The Santa Fe group began to dream of an institution focused on the vacuums between established fields and on the "emerging syntheses" that arise therein, as we came to call such new and growing areas. Finally, in 1984 the group sponsored two founding workshops, using the beautiful premises of the School of American Research in Santa Fe as a venue, at which a wide variety of candidate ideas and problems were expounded. The proceedings, published at first as an "advertising brochure" for the Santa Fe Institute, became the first book in the series the SFI eventually issued: *Emerging Syntheses in Science*, edited by Gell-Mann and David Pines, who had by then joined the group.

I remember those workshops not just with delight at meeting a large, diverse and congenial group of like-minded people in fantastically beautiful surroundings, but also with pleasure at discovering what one might call the "SFI secret weapon": Almost without exception, the more eminent, the more deeply committed, the more successful within a given field a scientist is, the more eager that scientist is to relate to scholars outside his or her field, and the more open he or she is to the Santa Fe message. It was rare indeed for us to identify a first-rate scientist in any field who we felt could contribute to our work and then to find that person was not happy to join. The *more* mature and self-confident a scientist is, the *less* that scientist feels that his or her narrow field contains the whole of knowledge.

George Cowan was chosen as president—since, in the beginning, it was his idea—and Murray as chairman of the board; along with a tiny bank account from a few private contributors, that was the institute. From the first we had probably the highest ratio of scientific eminence, commitment and sheer competence to physical plant and actual funding since Galileo's Accademia dei Lincei, or Academy of the Lynx-eyed (that is, the far-seeing).

Gradually, however, through sessions organized with foundation help, proposals to agencies and so on, we have reached an annual budget of \$2–3 million, coming from at least four disparate sources as well as private contributions.

We run workshops, summer schools and residential programs, much on the pattern of such institutions as Woods Hole, the International Centre for Theoretical Physics in Trieste and the Institute for Theoretical Physics in Santa Barbara. A few postdocs and a number of visiting scientists from our "external faculty" participate in programs whose real core is usually a network of like-minded people nationwide.

In much of our work we have identified a common theme that we call the "complex adaptive system." We see common behaviors in systems as diverse as biological populations, economics, organisms and the immune system, as well as adaptive computer programs such as those invented by John Holland. This commonality is something we try consciously to exploit in order to keep the different parts of our enterprise in intellectual contact with one another.

The most fully developed of our programs began as a result of a conversation, sponsored by economist Carl Kaysen, ex-head of the Institute for Advanced Study, between archaeologist Bob Adams, head of the Smithsonian Institution, and John Reed, CEO of Citicorp. Reed's profound distrust of the con-

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ventional economic wisdom that, in the early 1980s, landed Citicorp in such trouble with its Latin American debts predisposed him to be interested in helping to initiate a radical rethinking of global economics. He and Adams ran a one-day trial workshop at Santa Fe, where he eloquently expressed his concerns, seconded by one of his vice presidents, Eugenia Singer, who later became a regular member of our group. This initiative led to two further workshops, headed by Ken Arrow, an economics Nobelist, and me, that brought together natural scientists of several kinds with economists, and to a continuing on-site program led in the first year (1987–88) by Brian Arthur of Stanford. One activity we have run is the Santa Fe Double Oral Auction Tournament, a test bed for intelligent economics computer programs engineered by Richard Palmer and John Rust.

This is the best-known and best-funded SFI program, but we have a lot of other successful activities. Stu Kauffmann keeps a program going on molecular evolution and is on site this year with several visitors and a postdoc; theoretical immunology is a continuing interest that we share with researchers at Los Alamos National Laboratory along with Alan Perelson; our adaptive computation work has led to an offshoot at the University of Michigan led by Holland; and in some generalized sense the whole problem of adaptive, intelligent computers occupies a variety of our people, among them Kauffmann, Norman Packard, Doyne Farmer and Chris Langton (who has run a sequence of successful "artificial life" workshops with, for instance, 4H Club-type prizes for the most successful artificial animals or plants). We have also run three successful summer schools and one winter school on complexity science, in all of which Dan Stein and Erica Jen played leading roles.

I have slighted for want of space many other activities—for instance, our explorations in archaeology, in linguistics and in quantum measurement theory, all fostered by Gell-Mann, as well as a hopeful program on global survivability, begun by Cowan.

George Cowan has now turned the presidency of the Santa Fe Institute over to Ed Knapp, and in new and expanded premises in another part of Santa Fe, we head into our next five years. We continue to believe that we hold the world record for ratio of intellectual effervescence to funding. ■